Figure S1. Time series of the monthly Walker circulation intensity based on the STRF index, that is the vertically averaged value of the stream function $\psi_z$ over the western and central Pacific ($150^\circ$E – $150^\circ$W), and between 1000 – 100 hPa ($10^{10}$ kg s$^{-1}$). Different colored lines represent different models. Note the lack of obvious transients at the start of the simulations. Some models (BNU-ESM, CanESM2, GISS-E2-R, MIROC-ESM, HadGEM2-ES) have strong annual variability in STRF, while others show weak seasonality (CCSM4, NorESM1-M, IPSL-CM5A-LR).
**Figure S2.** Time series of the annual Walker circulation intensity indices based on the $\Delta$SST index. Different colored lines represent different models.
Figure S3. The mean state of Walker circulation during 50 years in three experiments for the 8 models. Color bar indicates the value of averaged zonal mass stream-function \(10^{10}\) kg s\(^{-1}\). Left shows \textit{piControl}, while center and right column respectively indicate the anomalies relative to \textit{piControl} for \textit{G1} and \textit{abrupt4\times CO2}.
experiments. Warm color (positive values) indicate a clockwise rotation and cold color (negative values) indicate an anticlockwise rotation.

Figure S4. The mean state of Hadley circulation during 50 years in three experiments
for the 8 models. Color bar indicates the value of averaged meridional mass stream-function \((10^{10} \text{ kg s}^{-1})\). Left shows \textit{piControl}, while center and right column respectively indicate the anomalies relative to \textit{piControl} for G1 and \textit{abrupt4}×\textit{CO}_2 experiments. Warm color (positive values) indicate a clockwise rotation and cold color (negative values) indicate an anticlockwise rotation.

Figure S5. Model ensemble mean meridional stream-function without GISS-E2-R in JAS (left) and JFM (right). Top shows \textit{piControl}, while center and bottom row respectively indicate the anomalies relative to \textit{piControl} for G1 and \textit{abrupt4}×\textit{CO}_2 experiments. Color bar indicates the value of averaged meridional mass stream-function \((10^{10} \text{ kg s}^{-1})\). Warm colors (positive values) indicate a clockwise rotation and cold colors (negative values) indicate an anticlockwise rotation.
**Figure S6.** The vertically averaged of zonal mass stream-function under ENSO. For El Niño or La Niña conditions, blue line in each panel represent the vertically averaged of zonal mass stream-function \((10^{10} \text{ kg s}^{-1})\) under \textit{piControl}. Red line in left two column is \(G1\) and right two column \textit{abrupt4} \(\times CO_2\). Thick lines denote locations where circulation changes are significant at the 95% confidence level. The 16%-84% range across the 8 individual models are show by light blue shading.
Figure S7. The vertically averaged of meridional mass stream-function under ENSO.

For El Niño or La Niña conditions, blue line in each panel represent the vertically averaged of zonal mass stream-function ($10^{10}$ kg s$^{-1}$) under piControl. Red line in left two column is G1 and right two column abrupt4×CO$_2$. Thick lines denote locations where circulation changes are significant at the 95% confidence level. The 16%-84% range across the 8 individual models are show by light blue shading.
Figure S8. Mean correlation between yearly STRF and global gridded 2 m temperatures for 100 years of piControl (left column), and 30 years of G1 (middle column).
and abrupt4×CO₂ (right column) experiments for 8 models.

**Figure S9.** Hadley intensity mean model anomalies versus the Tibetan Plateau (26°N-39°N, 73°E-104°E) minus tropical ocean (5°S-5°N, 180°W-180°E) temperature for the northern Hadley cell (left) in JFM and the southern Hadley cell in JAS (right). Positive value of Hadley intensity indicate Hadley circulation strengthening regardless of the direction.